Using this reduced speech bandwidth, one can expect 2 or 3 (shared or exclusive) new R.F. voice channels for each single radio voice channel now in use or planned. If this new system is largely or universally (and also internationally) adopted voluntarily or by official mandate, it should help considerably in beating the curr-end radio band availability "crunch". Likewise, when it can be utilized in conjunction with any other techniques that may be adopted now and in the future, it will further assist in alleviating the current and future problems defined by this and other Rule Making Procedures. Metaphorically-speaking, it may well become the proverbial "better mouse trap",re voice communications.

A tape recording of the standard telephone voice band vs. the new compressed speech system has been provided to the FCC Chief Engineer, Office of Engineering & Technology, (also to the FBI by request).

Four copies of this submittal are provided as stipulated, in addition to this original copy, together with enclosures.

Sincerely,

J.P. Neil

J.P. Neil, P.E. (KN6B)

TELEPHONE NETWORK INTERFACE
EQUIP. & SYSTEMS DESIGN APPLICATIONS

FCC PART 68 REGISTRATIONS

ACOUSTIC STUDIES & E.I.R.'S
ENVIRONMENTAL NOISE PROBLEMS

J. P. NEIL, P. E.
CONSULTING ENGINEER

2336 HILO COURT
MT. VIEW, CA 94040

TELEPHONE (415) 967-7579

FEB. 17, 1993

NARROW BAND VOICE COMMUNICATIONS

OVERVIEW

The world is accustomed to telephone, radio, TV and Satellite speech quality as determined many years ago by Bell Labs. and other experts in this field. In electronic communications systems, in landline (carrier) and especially radio and other non-wire transmission systems, this limits the channel bandwidth available, in the long overcrowded spectra.

Under a new Patent(5,142,580), this overcrowding can be reduced and channel widths lowered (i.e. more speech channels (or speech plus data) can be made available. For those with technical backgrounds, current common-carrier landline and radio voice circuits, typically use a telephone bandwidth of 200 Hz (Hertz) to 3400 Hz. The FCC specifies this voice range in Part 68 regulations.

However, in actual fact, all that is required for good speech communications, is adequate (about 75% min.) syllable, word and sentence integrity, plus recognition of the speaker's voice. This is readily obtainable with suitably-chosen speech bandwidths, as appropriate to the applications. It also includes aids to the "hard of hearing".

Under this new Patent 5,142,580 of 8/25/92,speech bands are arbitrarily compressed to much more narrow limits than the standard common-carrier range for local/long distance networks mentioned above, while still retaining all the necessary voice communications characteristics.

The bulk of speech power is contained between about 200 Hz and 1000 Hz. The peak level for both male and female voices is generally around 300 to 500 Hz. Many people with hearing impairments, especially older ones, lose higher frequency acuity, but do hear the lower ones within the highest power region noted above., with the help of hearing aids.

This system capitalizes on the bulk speech power maximum power region. Though based on logarithmic formulae, it can be adjusted in total bandwidth for specific purposes. In technical terms (see graph), the lab. prototype has a bandwidth of only 340 Hz at the "3 db points"; that is from around 410 Hz. to 750 Hz and the additional level emphasis, but nevertheless completely recognizable, clear and absence of of sideband noises. Obviously there are many future advantages this method can implement.

The main applications are for short or long distance communications by landlines or radio (commercial, industrial, business, Amateur, military, Satellite and ship to shore, ship to aircraft and aircraft to aircraft/land) plus cellular radio.

With the shortage of further available radio, etc. communications spectra, this

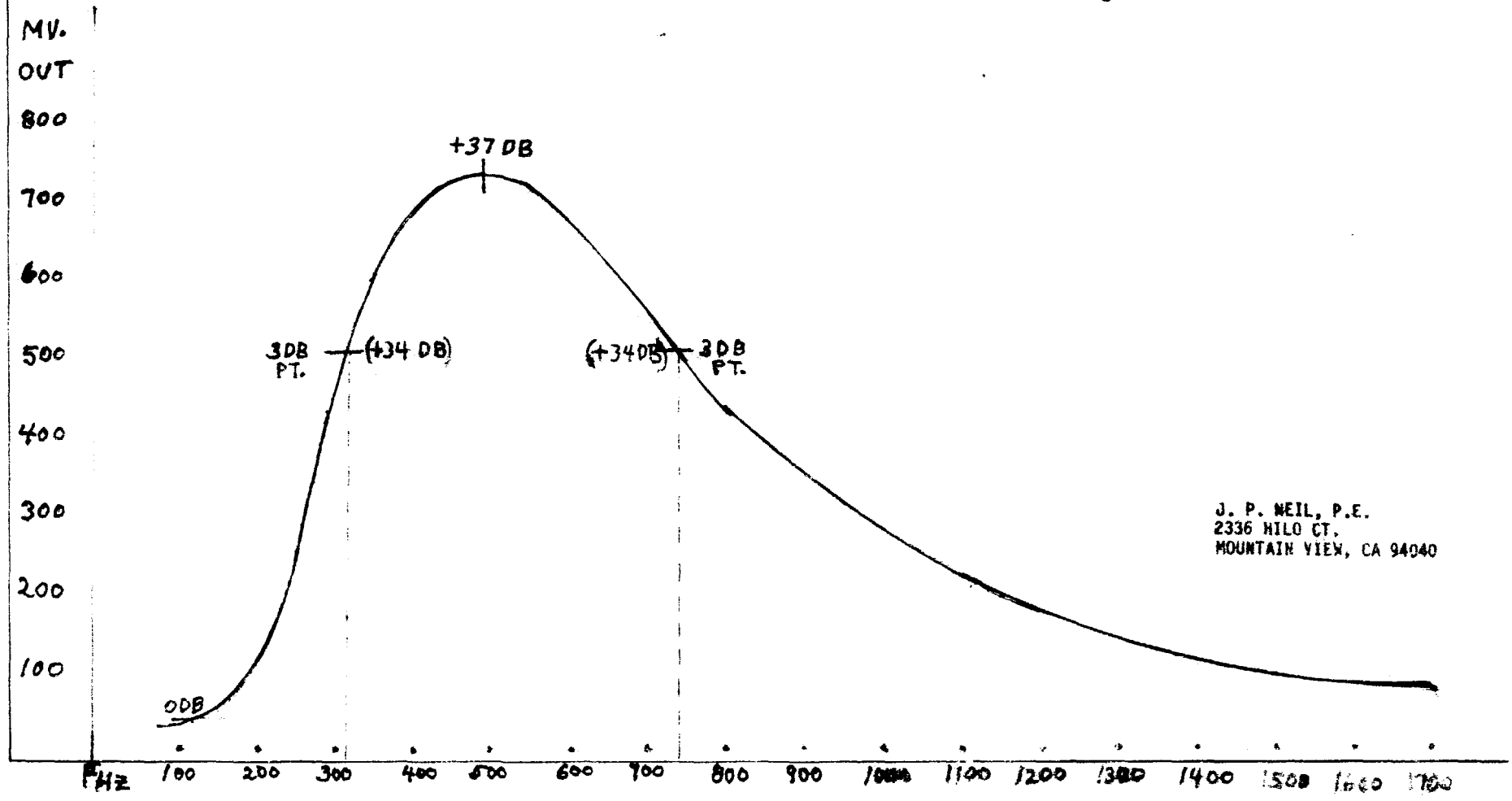
VOICE BAND REDUCTION APPARATUS & METHOD

U.S. PATENT NO. 5,142,580

ORIGINAL TEST UNIT BAND PASS SHAPE

INPUT SIGNAL CONSTANT 0.1 VOLTS

NOTE: The bulk of speech power is located between about 200 Hz and 1 KHz. The curve peak power was intentionally located at speech power approximate location to take advantage of this factor.



Interesting New Products

EXCERPT FROM FCC PART 68 BULLETIN

We just received an application for a T-1 digital framer from **Multiaccess** for interfacing T-1 inputs to the Switched Megabit Digital Services (SMDS) network. Also, **StrataCom** sent in an application for an interface to the Frame Relay service that multiplexes up to 24 channels of 56 or 64 kbps inputs. **Phil Neil**, who does Part 68 compliance testing, sent me a copy of his recent patent which permits compression of the standard 200 - 3400 Hz voice band used in telephony to much narrower limits without loss of comprehension. He presented technical testimony of a ham associate who says that, when using Neil's Narrowband Voice System, he was able to communicate with Neil 100%; that there was an improvement in signal-to-noise ratio; that the effective bandwidth was reduced by 67%while utilizing only one-third of the spectrum normally occupied by single sideband amateur radio transmissions. Phil apparently uses a clever combination of a clipping circuit and a combination of bandpass filters to accomplish this improvement. He sent me a test tape in which he compares the voice quality of the standard 3 kHz voiceband with his reduced 1 kHz bandwidth device. The results were exceptionally good.

MEMORANDUM FOR RECORD January 3, 1991

To: Who It May Concern

I have had fourteen years of communications and electronics experience and am employed as an engineering supervisor with the U. S. Government, Department of the Air Force. Our role is provide a systems programs and analysis function for logistics support for a worldwide satellite tracking network headquarters at Peterson Air Force Base, Colorado.

I was asked to comment on Mr. J. P. Neil's Narrowband Voice System.

In my opinion, Mr. Neil's Narrowband Voice System as applied to amateur-radio narrowband single sideband transmission, for example, performed as advertised and in accordance with the narrow bandwidth specified. I participated with Mr. Neil in on the-air experimentation with the goal of design improvement towards optimum results which were achieved in my view. I was able to recognize his voice, understand and communicate with him 100% when operating in this mode. An improvement in signal-to-noise ratio was quite apparent. The effective bandwidth appeared to be reduced by 67%, utilizing only one-third of the spectrum normally occupied by single sideband amateur radio transmissions of this sort.

It appears the value added gained from his system would be to permit many more radio transmitters, perhaps three times a normal amount, to occupy any given portion of the radio frequency spectrum.

R. E. Hunt (AG6QR)

13158 Diericx Drive
Mtn. View, CA 94040
PHONE: 415/752-3871 (Office)

The United States of America

The Commissioner of Patents and Trademarks

Has received an application for a patent for a new and useful invention. The title and description of the invention are enclosed. The requirements of law have been complied with, and it has been determined that a patent on the invention shall be granted under the law.

Therefore, this

United States Patent

Grants to the person or persons having title to this patent the right to exclude others from making, using or selling the invention throughout the United States of America for the term of seventeen years from the date of this patent, subject to the payment of maintenance fees as provided by law.

Acting Commissioner of Patents and Trademarks

Attest

US005142580A

United States Patent [19]

Neil

[11] Patent Number: 5,142,580

[45] Date of Patent: Aug. 25, 1992

[54] VOICE BAND REDUCTION APPARATUS AND METHOD FOR INCREASING AVAILABILITY OF VOICE CHANNELS

[76] Inventor: J. Philip Neil, 2336 Hilo Ct., Mountain View, Calif. 94040

[21] Appl. No.: 680,035

[22] Filed: Mar. 28, 1991

Related U.S. Application Data

[63] Continuation of Ser. No. 325,239, Mar. 16, 1989, abandoned.

[51] Int. Cl.[5] G10L 3/02; H03F 1/42

[52] U.S. Cl. 381/29; 333/17.1

[58] Field of Search 381/29-47; 333/17.1, 17.2, 176, 178; 364/513.5

[56] References Cited

U.S. PATENT DOCUMENTS

2,903,515	9/1959	Smith	381/41
3,084,327	4/1963	Cutler	325/45
3,297,882	1/1967	Broadhead	307/88.5
3,524,081	8/1970	Campanella	307/317
3,760,196	9/1973	Nomoto et al.	307/237
4,166,924	9/1979	Berkley et al.	179/1 P
4,255,620	3/1981	Harris et al.	179/15.55 P
4,383,229	5/1983	Jones	333/176

OTHER PUBLICATIONS

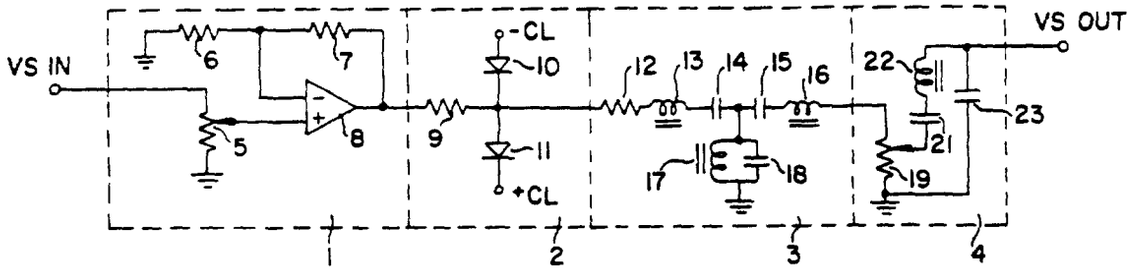
Horowitz et al., The Art of Electronics, Cambridge University Press, p. 42, 1980.

Primary Examiner—Dale M. Shaw
Assistant Examiner—Michelle Doerrler
Attorney, Agent, or Firm—Herbert L. Lerner; Laurence A. Greenberg

[57] ABSTRACT

An apparatus for frequency band reduction of a voice signal having an upper and lower band limit including a voice signal input, a clipping circuit for clipping the positive and negative peaks of the voice signal connected to the voice signal input. A bandpass filter is connected to the clipping circuit for rejecting harmonics created by the clipping circuit. A low and high end roll off filter device is provided for producing a given decibel/octave frequency roll off at the lower band limit; and the geometric mean value of the upper and lower band limit falls within a given lower and a given upper frequency range.

8 Claims, 4 Drawing Sheets



VOICE BAND REDUCTION APPARATUS AND METHOD FOR INCREASING AVAILABILITY OF VOICE CHANNELS

This application is a continuation of application Ser. No. 325,239, filed Mar. 16, 1989, now abandoned.

The invention relates to an aparatus and a method for frequency band reduction of a voice signal, and more particularly to frequency band reduction by means of clipping the peaks of a voice signal and rejecting the harmonics created by the clipping, by means of a bandpass filter having special characteristics according to the invention. As a result the average voice energy level is increased, leading to better noise reduction and savings in frequency band use.

BACKGROUND AND PRIOR ART

U.S. Pat. No. 4,383,229 shows clipping only of specific harmonics, which is different from the method disclosed herein.

Using clipping of the peaks of a voice signal followed by filtering in a bandpass filter has long been known. U.S. Pat. No. 3,297,882 shows such an arrangement. The latter patent shows only clipping and pass band filtering. Clipping and band-filtering alone however has never gained widespread use as means for band reduction due to the fact that clipping and band filtering according to the known art has resulted in poor voice signal quality and loss of speaker recognition.

Voice band reduction clearly is a much desired object, since it makes possible an increased number of voice channels within a frequency band of a given width. This is especially true in radio communication, including satellite communication, and carrier-based land lines wherein the available bandwidth is constrained by the availability of usable frequency bands.

Clipping of a voiceband signal according to the instant invention leads to increased voice energy levels especially above 1000 Hz where normal speech energy levels tend to roll off.

Unlike the prior art, in the instant invention clipping is applied on a broad band basis and the harmonics created in the clipping process are eliminated by means of suitable filtering as disclosed in more detail in the following disclosure.

It is therefore a primary object of the instant invention to provide apparatus and a method of frequency band reduction of a voice signal having a given original bandwidth without significant loss of voice signal quality and speaker recognition.

SUMMARY OF THE INVENTION

The apparatus for voice band reduction includes a voice signal clipping circuit that clips the positive and negative 2 peaks of the voice signal, followed by a bandpass filter having upper and lower band limits such that the square root of the product of the band limits falls within a range of 650 and 900 Hertz and both the low and high end of the band has a roll off of 6 decibel/octave. In other words the geometric mean value of the band limit frequencies is within the range of 650-900 Hertz. The stated range has the dimension of Hz, but is not equal to the signal bandwidth, which also has the dimension of Hertz.

The band pass filter serves to remove the harmonics created by the clipping process, which would otherwise lead to severe distortion of the voice signal.

A low and high end roll off at a rate of 6 decibel/octave is necessary in order to maintain an acceptable voice signal quality. Without the roll-off, the clipping and bandpass filtering causes the signal to sound "boomey" and "hollow" to an unpleasant degree and causes loss of speaker recognition. The low and high end roll is necessary to obtain the desired frequency band reduction.

The clipping of the peaks of the voice signal causes an evening-out of the variations in the signal energy of the voice signal. The human voice is naturally modulated such that the root-mean-square value of the voice energy constantly fluctuates within a wide range during conversation, resulting in a relatively low average energy level. The peak energy level of most transmission apparatus is limited to a given upper value. The clipping and filtering of the voice signal therefore operates to increase the average voice signal level which is beneficial in overcoming noise and improving speech comprehension.

The use of a geometric mean value of the signal band in the range of 650-900 Hertz is lower than that of conventional non-reduced telephony voice channels, which usually have a band-width of typically 300-3000 Hertz, giving a geometric mean value of 949 Hertz. In reducing the signal bandwidth by clipping and filtering, the applicant has found that it is important to move the geometric mean value of the band limits downward by controlling both the upper and lower band limit. In this way a voice band of for example 300 to 2000 Hz has been found to be attainable without significant loss of voice quality and speaker recognition. Such a band-limited signal has a bandwidth of 1700 Hertz, which is a significant band reduction compared with the conventional band width of 2700 Hertz, resulting in 1.6 times more usable voice channels within a given frequency band. It has been found that the voice passband can be reduced to as low as 1 Hertz while still retaining useable syllabic, word and sentence articulation in addition to some degree of speaker recognition.

In accordance with the inventive concept the bandpass filter and the filter means for creating the 6 decibel/octave roll-off can be realized by means of active or passive filters or a combination thereof, or by means of a single filter or several cooperating filters.

The clipper circuit can advantageously be realized by means of two anti-parallel silicon diodes connected at one end to the input of the band pass filter and at the other end to ac-ground, or by means of two clipping diodes, having their respective anode and cathode joined and connected to the input of the band pass filter and their respective cathode and anode connected to a positive and negative clipping potential of equal magnitude for the purpose of symmetrical clipping.

In accordance with a further feature, the band-reducing apparatus according to the invention is well suited to be combined with the transmitting apparatus of land-based carrier systems for adding further voice bands. The band-reducing apparatus is especially well suited to be incorporated into radio transmitters for maritime and airborne radio communications systems.

When used in radio communication the invention has the further significant economic advantage that the invention can be implemented by adaptation of only the transmitting apparatus while no decoding or signal processing is required in the receiving apparatus.

In a further improved arrangement of the invention a controlled degree of rolloff is applied at both ends of the

The right hand ordinate is graded in "liminal units" which is an approximate measure of the quality of articulation of a band-reduced voice signal. One liminal unit is a rough measure of the just discernable increment in voice articulation.

The upper line labelled "quality" indicates band limits for a voice signal of relatively high grade, still with band limits giving the highest degree of articulation for a given bandwidth.

FIG. 4 shows graphs of an unclipped voice signal (upper curve) and a clipped and band-filtered signal according to the circuit shown the FIG. 2 (lower curve). It has a band-width of 300 to 2050 Hertz and has been judged by a panel of listeners to provide a good

given lower and a given upper frequency range 950 to 1200 Hertz.

2. Apparatus according to claim 1 wherein said, band-pass filter is a passive filter of the third order.

3. Apparatus according to claim 1 wherein said, band-pass filter is an active filter of the third order.

4. Apparatus according to claim 3 wherein said limiter circuit includes first and second dipping diodes joined at their respective cathode and anode in a junction point connected to an input of said active filter, and conected with their respective anode and cathode to a ground potential for clipping the peaks of the voice signal.

5. Apparatus according to claim 1 wherein said high

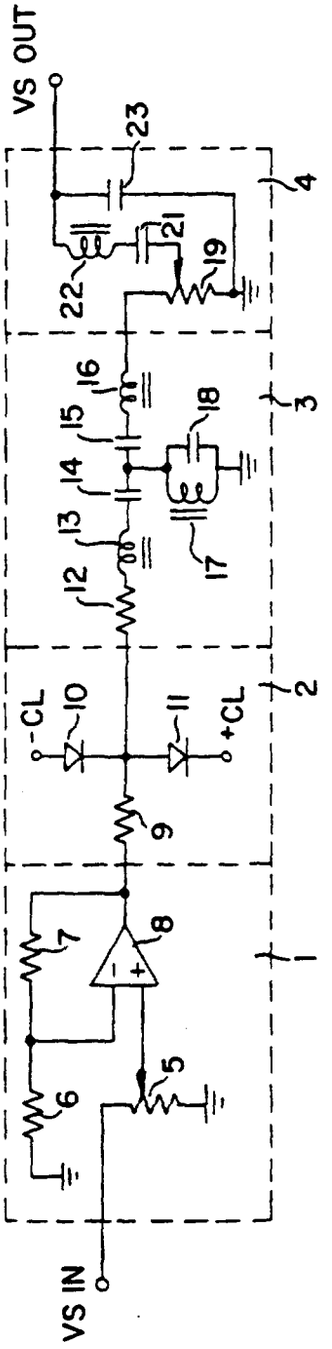


FIG. 1

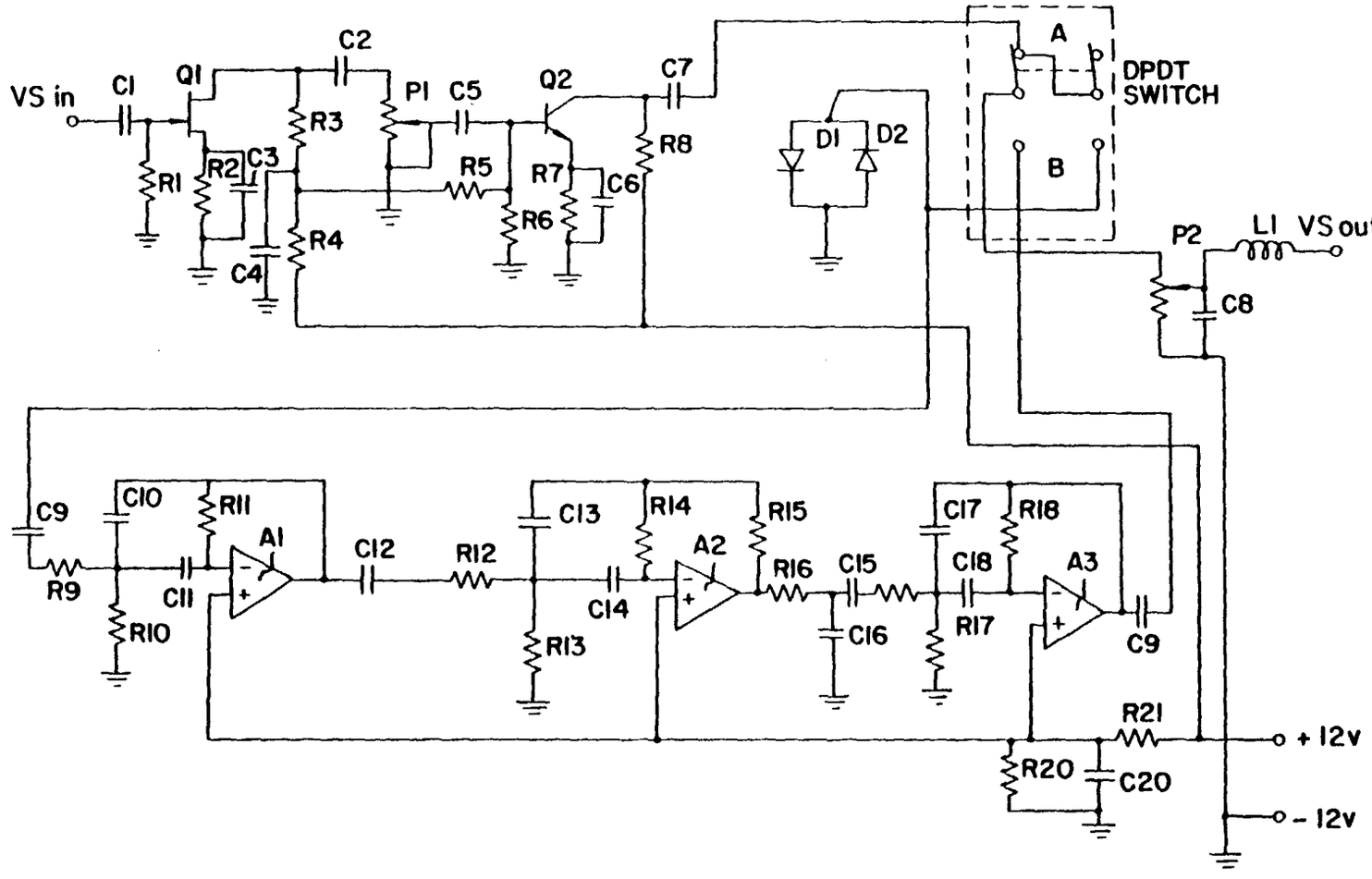
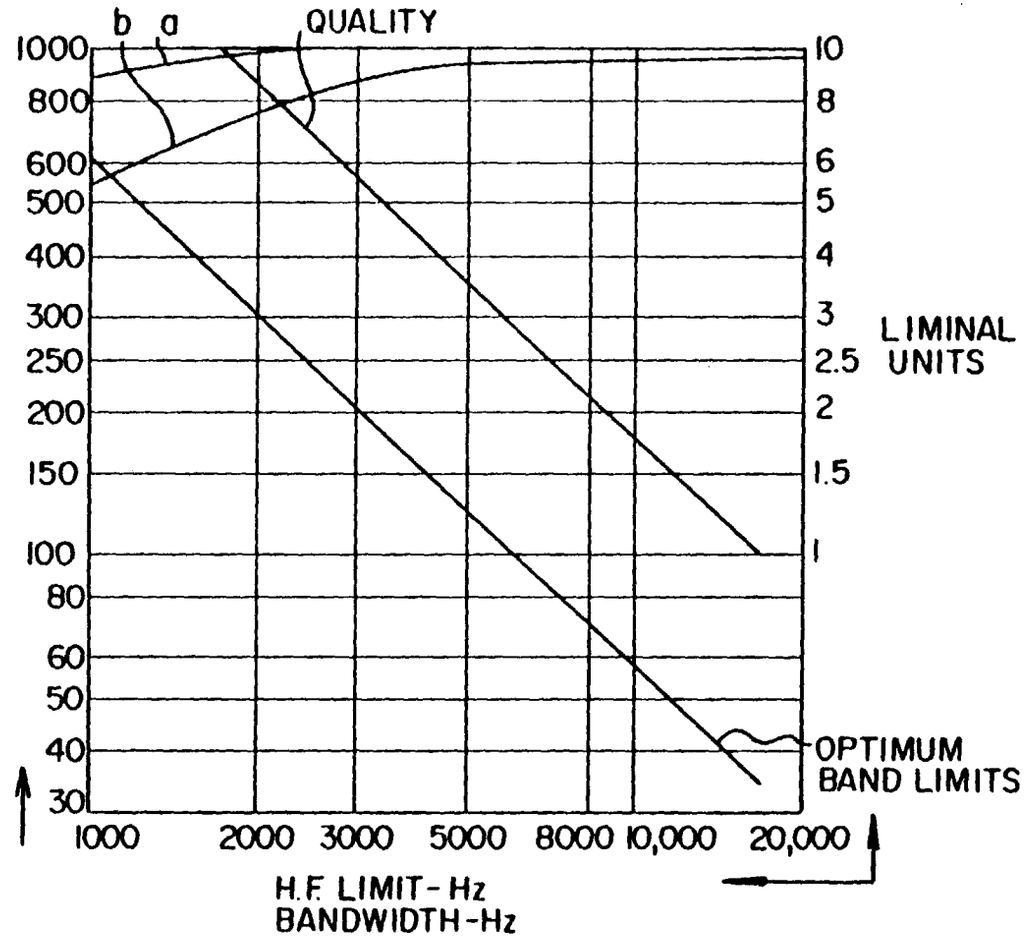

VS in
C1
Q1
C2
R1
R2
C3
R3
C4
R4
P1
C5
R5
Q2
R6
R7
C6
C7
R8
D1
D2
A
DPDT
SWITCH
B
P2
L1
VS out
C8
C9
C10
R11
A1
R9
C11
R10
C12
R12
C13
R13
R14
A2
C14
R15
R16
C15
C16
C17
R18
C18
R17
A3
C9
R21
R20
C20
+ 12v
- 12v

FIG. 2

FIG. 3


b
a
QUALITY
1000
800
600
500
400
300
250
200
150
100
80
60
50
40
30
10
8
6
5
4
3
2.5
2
1.5
1
LIMINAL UNITS
OPTIMUM BAND LIMITS
1000
2000
3000
5000
8000
10,000
20,000
H.F. LIMIT - Hz
BANDWIDTH - Hz

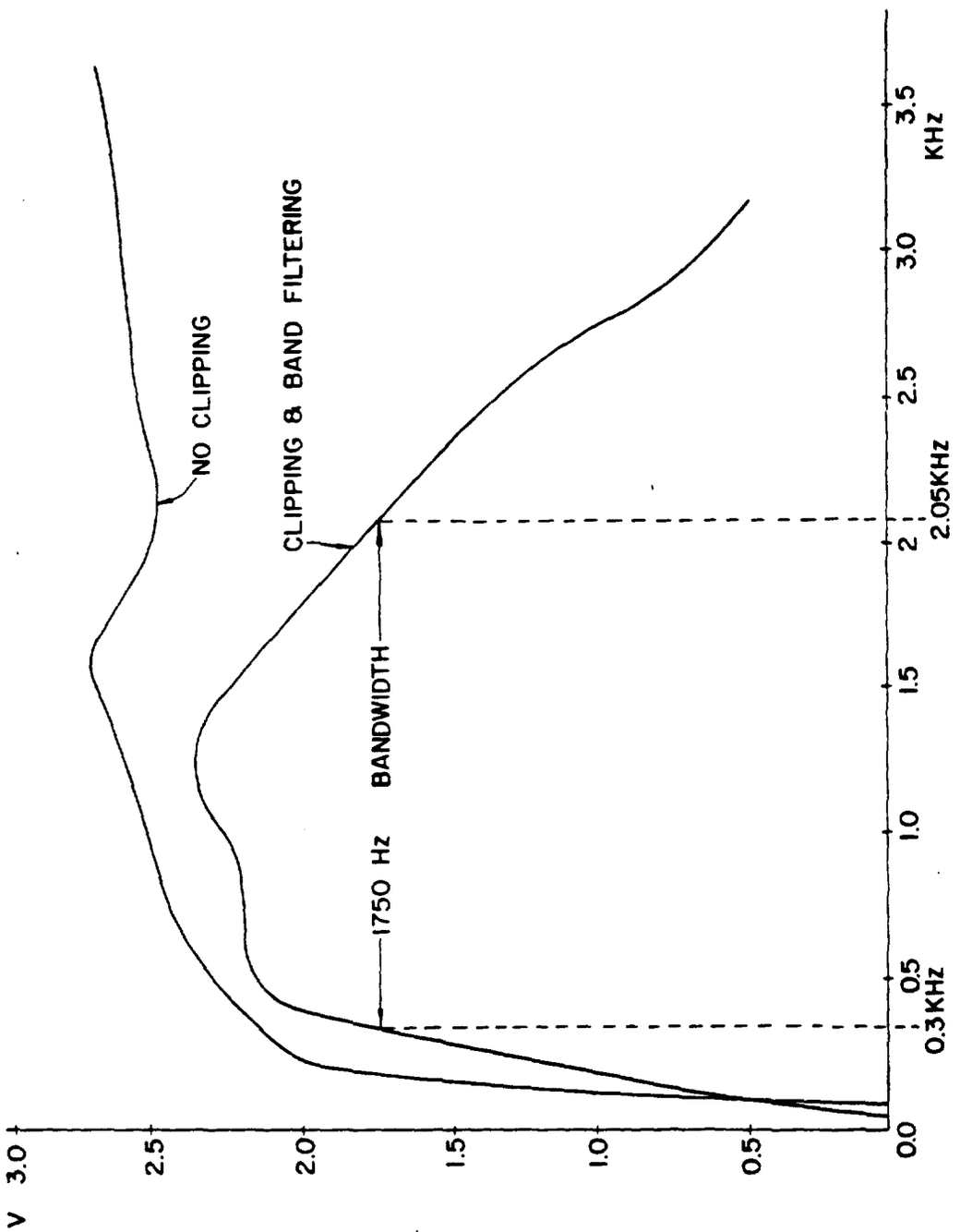

V
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.5
0.3KHz
1.0
1.5
2
2.05KHz
2.5
3.0
3.5
KHz
NO CLIPPING
CLIPPING & BAND FILTERING
BANDWIDTH
1750 Hz

FIG. 4